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Discussions

Interactive comment on "Flow dynamics around downwelling submarine canyons" *by* J. M. Spurgin and S. E. Allen

J. Kämpf (Referee)

jochen.kaempf@flinders.edu.au

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General comments:

The authors study the flow dynamics of "downwelling" submarine canyons. Overall, I think the study subject is interesting, but the authors should be careful with their interpretations. In the case of upwelling canyons, the upwelling consists of a continuous flux of denser water onto the shelf. The downwelling situation discussed by the authors is something completely different. Based on the information provided, instead of a continuous vertical flux, the density/nutrient anomalies discussed by the authors do not

seem to change over time. Hence, what is discussed in the paper seems to be rather a transient adjustment of the density field void of any vertical fluxes afterwards. Or are there any continuous vertical fluxes involved? If so, where do they occur? Do the canyons simulated really create a continuous downwelling flux? If not, the title could be misleading.

Most of the numerical case studies failed to create any significant upwelling features. So, why does the Catalan continental margin (NW Mediterranean Sea) support important commercial fisheries? Did the study findings reveal any new clues explaining this feature?

The abstract states the introduction of a new parameter to determine the significance of vertical variations in stratification. My feeling is that the only aim of this statement is to give the paper some flair of novelty. To call the ratio of buoyancy frequencies a new parameter is clearly exaggerated, in my view, noting that the parmeter is not mentioned in the summary.

My assessment is that the paper needs some reworking before it can be published.

Specific comments:

Page 3: Note that Kämpf (2006) also considered downwelling conditions. This study should be discussed (or, at least, mentioned) in the text. Reference: Kämpf, J., 2006. Transient wind-driven upwelling in a submarine canyon: a process-oriented modelling study. Journal of Geophysical Research, 111, C11011, doi:10.1029/2006JC003497

Page 3:"oscillatory flow usually leads to weak upwelling (Boyer et al., 2004)". Note that Kämpf (2009) demonstrated that Boyer et al.'s conclusions were incorrect and that oscillatory flows do not induce net upwelling fluxes. All that happens is that denser water transiently appears on the outer shelf. Reference: Kämpf, J., 2009. On the interaction of time-variable flows with a shelf-break canyon. Journal of Physical Oceanography. 39(1), 248:260, DOI: 10.1175/2008JPO3753.1

Page 7: I presume that the initial T,S and nitrate distributions were horizontally uniform. If this is so, please state this in the text and show profiles.

Page 8: The “new” parameter chi depends on z. If you say this parameter is negative, do you mean over the entire depth range?

Page 15: “Model simulations exhibit three types of horizontal circulation: (1) formation of an anti-cyclonic eddy within the canyon, (2) cyclonic circulation everywhere within the canyon and (3) weak circulation everywhere within the canyon.” This classification does not make sense to me. Isn’t it that the baseline “smooth” circulation creates a cyclonic circulation within the canyon, and that stronger flows create the anticyclonic eddy? There is no third type.

Page 17: Vertical velocity. Does this include the vertical velocity induces by bottom-parallel flow; i.e. u*dh/dx+v*dh/dy?

Page 18: Density anomalies can be strongly influenced by cross-isobath mixing corresponding to “lateral mixing” in a sigma coordinate model. This artificial mixing can create bands of negative and positive values of density anomalies as in Fig. 8b. Please detail the treatment of horizontal mixing in the model.

Page 20: “There are various ways in which upwelling can be defined. Firstly, upwelling can be characterised as the net upwards movement of water in a region. Secondly, upwelling can be described as the net onshore movement of dense, cold (usually nutrient-rich) deep ocean water to the shallower coastal ocean.” This statement is confusing and partially false. All upwelling is associated with a net upward movement. One form is caused by a convergence of horizontal flow, the other from arises from cross-isobath lateral flow. Please rewrite this section.

Page 28/29: Nitrate anomalies. Pattern 2. In the text it says that positive density anomalies are found away from the canyon. In Figure 8d) these regions occur both upstream and downstream the canyon axis, in Figure 9b) positive nitrate anomalies

are found offshore and about 50 m above the seafloor. Are these the signatures of the same pattern? Where is the density anomaly in Figure 8 taken from? Is it depth averaged? Is the taken from the bottom-nearest grid cell? Please clarify what “pattern 2” is. Where does the localized upwelling occur and what causes it? Is it transient or continuous? What are the associated nutrient fluxes?

Table 7: How significant are the anomalies? Can they be quantified? Do they change over time, or do the vertical fluxes causing the anomalies cease over time?

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